

NOTES ON THE BIOLOGY AND IMMATURE STAGES OF
STENOPA AFFINIS QUISENBERRY (DIPTERA: TEPHRITIDAE)

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Abstract.—*Stenopa affinis* Quisenberry is reported for the first time from Nevada and from its heretofore unknown, perhaps sole, host plant, *Senecio multilobatus* Torrey and Gray (Asteraceae). This extremely rare, univoltine tephritid overwinters as larvae in mines in crowns of *Se. multilobatus* rosettes without forming galls, unlike its only known congener, *St. vulnerata* (Loew), which forms apical stem galls on basal shoots of a different species of *Senecio*. Pupariation occurs in early summer (June) in vertically oriented, open, frass-lined cells in crowns below ground level. Second and third instar larvae and puparia are described and illustrated for the first time. Distinctive characteristics of the larvae include newly discovered lateral sensory lobes on the gnathocephalon and antero-lateral groupings of five or six morphologically distinct sensilla on each body segment. *Tetrastichus* sp. (Hymenoptera: Eulophidae) were reared from puparia as gregarious endoparasitoids.

Key Words: Nevada, *Senecio multilobatus*, mines, crowns

Stenopa affinis Quisenberry is the much less common, less widespread, and less known of the two species in this genus in North America (Foote and Blanc 1963, Foote 1965, Novak and Foote 1975). The biology and immature stages of *St. vulnerata* (Loew) were described by Novak and Foote (1975), but very little has been published on *St. affinis*. We describe our admittedly incomplete knowledge of this rare tephritid gleaned from field observations and laboratory study of samples collected by RDG at a remote location in western Nevada visited only three times. Continued study of this species under these circumstances was deemed impractical considering the vast amount still to be learned about the biologies and ecology of other, much more common native Tephritidae currently under study by us in California.

Stenopa affinis was described from one male specimen collected in Colorado by

Quisenberry (1949). Foote (1965) catalogued a few additional specimens from Arizona and Colorado; whereas, Foote and Blanc (1963) reported no *St. affinis* and only three specimens of *St. vulnerata* from California and noted that the latter species was "found in southern Canada and nearly every state in the United States." The following records represent the first reports of *St. affinis* from Nevada (at a location just across the California border) and from an identified host plant: One female was reared from the crown of a mature *Senecio multilobatus* Torrey and Gray growing in shade under *Populus* spp. on the south-facing bank of a stream in Middle Canyon at 2690-m elevation east of Boundary Peak in the White Mountains, Inyo National Forest, Esmeralda Co., Nevada, on 10 vi 1987. One male and one female also were reared on 27 vii and 14 vii 1989, respectively, from puparia dissected from separate crowns collected at



Fig. 1. (A) Longitudinal cross-section through uninfested crown of *Se. multilobatus* (3.9 \times); (B) second instar larva of *St. affinis* in pith of upper crown of *Se. multilobatus* (7.8 \times); (C) puparium of *St. affinis* in cell in pith of crown of *Se. multilobatus* (3.1 \times).

the same location on 25 vii 1989. These three specimens reside in the research collection of RDG.

Stenopa vulnerata was reported from *Senecio aureus* L. by Novak et al. (1967) and Novak and Foote (1975), so the known hosts of both species of *Stenopa* are congeneric. The distribution of *Se. multilobatus* includes Arizona, California, Colorado, and Nevada in the southwestern United States (Munz 1974); *St. affinis* could be monophagous on this host. This contrasts with the widespread distribution of *St. vulnerata* in North America, which Novak and Foote (1975) noted was wider than that of *Se. aureus*, and thus, probably includes other species of *Senecio*. Laboratory dissection in 1988 of 78 rosettes of *Se. multilobatus* sampled at three locations between 3300- and 3400-m elevations on White Mountain on the California side of the border across from the Middle Canyon study site in Nevada detected no *St. affinis*; although, this fly, like its host plant, probably also occurs in the former state.

Another major difference was discovered in the biologies of the two species of *Stenopa*. Novak et al. (1967) and Novak and

Foote (1975) reported that *St. vulnerata* larvae form small stem galls near the apices of basal shoots arising from crowns; whereas, *St. affinis* is not a gall former. Instead, the larvae of *St. affinis* mine the parenchyma in the center of the crowns (basal underground stem and upper root) of their biennial or short-lived perennial host plants (Fig. 1A, 1B), without causing detectable tissue proliferation (Fig. 1A, 1B).

The life cycle of *St. affinis* largely was determined from laboratory dissections of 16 (8%) infested crowns of 200 overwintered rosettes sampled from Middle Canyon and nearby Trail Canyon on 19 v and 20 v 1988 and of 10 (20%) infested crowns of 50 postblossom plants sampled in Middle Canyon on 25 vii 1989. Like *St. vulnerata* (Novak and Foote 1975), *St. affinis* is univoltine.

Judging from our plant samples and the adult emergence recorded above, *St. affinis* probably oviposited from mid- to late summer (early August through mid-September) in Middle Canyon. Tracing mines of younger overwintering larvae (Fig. 1B) in 1988 indicated that oviposition occurred in an axil between two basal leaves on a solitary

rosette or on one or more rosettes arising from 2- or 3-year-old crowns. Oviposition also occurred after flowering and fruiting by *Se. multilobatus* had ceased by late July, 1989.

Upon hatching, the larvae tunneled basipetally down the leaf trace into the pith parenchyma, then sinuously downward through the vertical series of whitish septa alternating with narrow, open spaces that form a natural cavity in the upper crown (Fig. 1A). The tunnels continue vertically into the more solid parenchyma of the root pith and are open, smooth-walled, and lined with reddish-brown, fine-grained frass (Fig. 1C). The larvae overwinter as second and third instars, this range probably being reflective of a protracted oviposition period or differential rates of larval growth. Upon resumption of feeding and growth during spring, the larva eventually excavates an open, ellipsoidal, vertically oriented, centrally located, frass-lined cell, 16 of which averaged 10 (range, 7–13) mm long by 4 (range, 3–6) mm wide, where it eventually pupariates (Fig. 1C). An exit tunnel 2–3 mm wide averaging 6 (range, 4 to 13; $n = 15$) mm in length tapers upward from each cell and ends in a cuticular window formed as a slit between two adjacent stem bases or as a frass plug in the stump of a single central flower stalk. The plug is pushed outward or the window is broken by the emerging adult. The larvae pupariate head-upward, with their posterior ends 3 to 5 mm above the base of the vertical cell; this lower part of the cell often is packed solid with frass. Twenty-two larval tunnels reached a mean depth of 15 ± 0.5 mm ($\bar{x} \pm SE$) below ground level.

Larvae of unidentified genera and species of Curculionidae and Gelechiidae as well as *Melanagromyza* sp. (Diptera: Agromyzidae) also mined the crowns of *Se. multilobatus* at our California and Nevada sample sites. Also, one puparium each collected in 1988 and 1989 yielded gregarious, endopar-

asitoids identified as *Tetrastichus* sp. (Hymenoptera: Eulophidae).

The adult female pictured in Fig. 2 lived for 49 days caged at room temperature in a clear plastic, 1.1 l, screen-topped container provisioned with two fresh, open capitula of *Aster spinosus* Bentham as sources of pollen and as resting places. Honey was striped on the inner lid, and water was provided via a wick immersed in a basal reservoir. This female and the male reared in 1989 were very active fliers, immediately seeking to fly upwards when freed, and too active to photograph except when confined to a petri dish (Fig. 2). Too few adults were reared to study their courtship and mating behavior, as Novak & Foote (1975) described for *St. vulnerata*.

One second and two third instar larvae and 14 empty or intact puparia dissected from crown samples were used to describe these immature stages using scanning electron microscopy (SEM). Larvae were killed in 70% EtOH serially rehydrated to distilled water, fixed in a 2% solution of osmium tetroxide for 24 h, dehydrated to 100% EtOH, critically point dried, and mounted on stubs with colloidal graphite (Headrick and Goeden, in press). Specimens were examined and micrographs prepared at 15 kV accelerating voltage, unless otherwise noted, using Polaroid 55 P/N film on a JOEL JSM-C35 SEM located in the Department of Nematology, University of California, Riverside, or on a Phillips 515 SEM, located in the Department of Biology. No eggs or first instars were observed. The mature third instar is described in detail using the nomenclature and format adopted by Headrick and Goeden (in press); the second instar description is limited to observed differences.

Third instar.—This relatively large non-frugivorous tephritid (a single, mature larva measured 5.1 mm long and 1.75 mm wide), is elongate and uniformly cylindrical (Fig. 3A), rather than barrel-shaped as Novak and Foote (1975) described *St. vulnerata*. The



Fig. 2. Adult female of *St. affinis* (8.5×).

integument is translucent-white with a somewhat greyish cast. The body is smooth dorsally, with two or three folds per segment ventrally.

The mouth-hooks are heavily sclerotized, bidentate, and smooth. The dorsal rib of the median oral lobe tapers to a point anteriorly, and the ventral lobe is laterally flattened, smooth and without ventral papillae (Fig. 3B, arrow). Three cephalopharyngeal skeletons were 0.5 to 0.52 mm long. The gnathocephalon is cone-shaped, rugose, and superficially divided on its anterior face by a medial depression; the anterior edge holds numerous integumental petals dorsally surrounding the mouth-hooks (Fig. 3C, 1). The paired dorsal sensory organs are composed of a single papilla (Fig. 3C, 2); the paired anterior sensory lobes lie dorsal of the mouth lumen and hold the lateral sensory organ, the pit sensory organ and the terminal sensory organ, as is typical among non-frugivorous larval Tephritidae (Headrick, unpublished data).

Another pair of sensory organs are locat-

ed ventro-laterally on the edge of the gnathocephalon surrounding the mouth lumen (Fig. 3C, 3). These sensory organs are similar in form to the anterior sensory lobes with a ring-like structure bearing a pore sensillum, a papillate sensillum, and a fluted cone-like peg (Fig. 3D, 1, 2, 3). This pair of sensory organs is most likely homologous to the stomal sense organs described for larvae of *Anastrepha ludens* (Loew) (Diptera: Tephritidae) by Carroll and Wharton (1989), and the ventral sense organ of *Musca domestica* (Diptera: Muscidae) larvae described by Chu and Axtell (1972). However, there is enough difference in placement and structural detail to warrant not equating the pair of sensory organs on *St. affinis* with these other described sensory organs until further evidence demonstrates their homology.

The prothorax is rounded, smooth and has several sensilla. The anterior thoracic spiracle is located dorso-laterally on the posterior margin of the prothorax (Fig. 3E, arrow). It projects in a dorso-ventral fan-

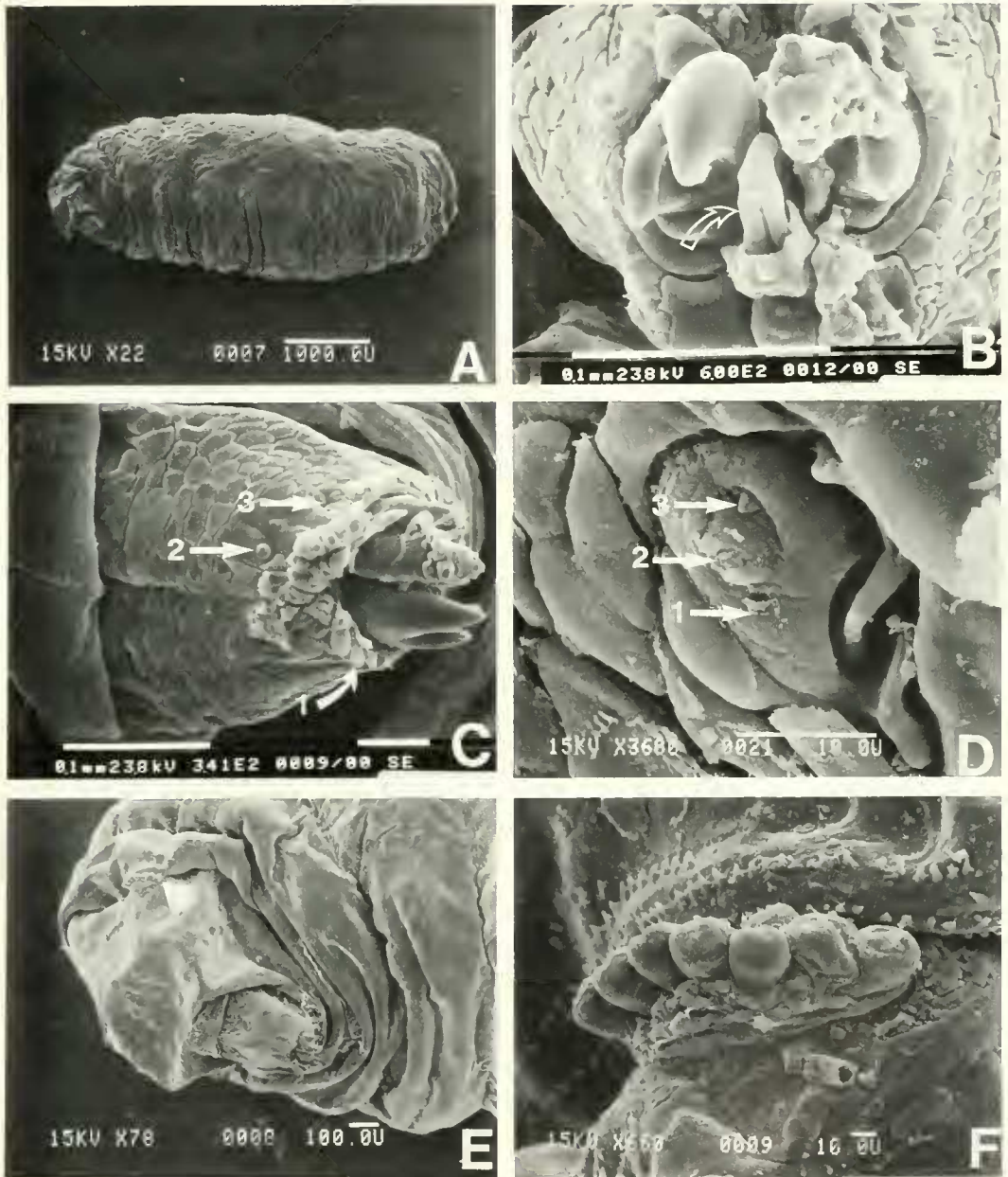


Fig. 3. Third instar larva of *St. affinis*. (A) Habitus; (B) anterior view, mouth region, arrow denotes median oral lobe; (C) gnathocephalon; 1—integumental petals; 2—dorsal sensory organ; 3—lateral sensory organ; (D) lateral sensory organ; 1—pore sensillum; 2—papillate sensory structure; 3—fluted, peg-like structure; (E) anterior end, arrow denotes anterior thoracic spiracle; (F) anterior thoracic spiracle.

shape bearing eight rounded papillae (Fig. 3F). This is distinct from the anterior thoracic spiracle of *St. vulnerata* which bears 24 to 26 scattered finger-like papillae (Novak and Foote 1975).

The body segments are demarcated by rows of minute depressions which circumscribe the body (Fig. 4A, arrow), and the intersegmental bands of acanthae are minute (Fig. 4A). Each segment bears an antero-lateral grouping of five or six morphologically distinct sensilla (Fig. 4B). The most anterior sensillum is single, wrinkled, and inverted; posterior to this is a group of three wart-like, rounded sensilla with a central pore (Fig. 4C) arranged in a vertical row; posterior to this row are one or two rounded papillate sensilla. These specific types and arrangements of sensilla have not been described for any tephritid larva. Ventrally, each segment also is invested with a pair of rounded sensilla, one on each side of the ventral midline. The caudal end is broadly truncate and bears the posterior spiracular plates dorsal to the transverse midline. Each spiracular plate bears three elongate-oval spiracular rimae and four interspiracular processes.

Second instar larva.—The single second instar examined measured ca. 3 mm in length and ca. 1.5 mm wide (Figs. 1B, 5A). It was translucent white and more barrel-shaped than the third instar. Most structures were similar in size and number to that of the third instar, except for subtle degrees of morphogenesis, which can be quite pronounced between stadia in other tephritid larvae (Carroll and Wharton 1989, Headrick and Goeden in press and unpub. data). The gnathocephalon and mouthparts are similar to that described for the third instar (Fig. 5B, 1). The gnathocephalon is rugose and bears three sensory organs including the lateral sensory organs (Fig. 5B, 2). The anterior thoracic spiracle bears eight somewhat underdeveloped papillae (Fig. 5C).

Puparium.—Fourteen puparia averaged

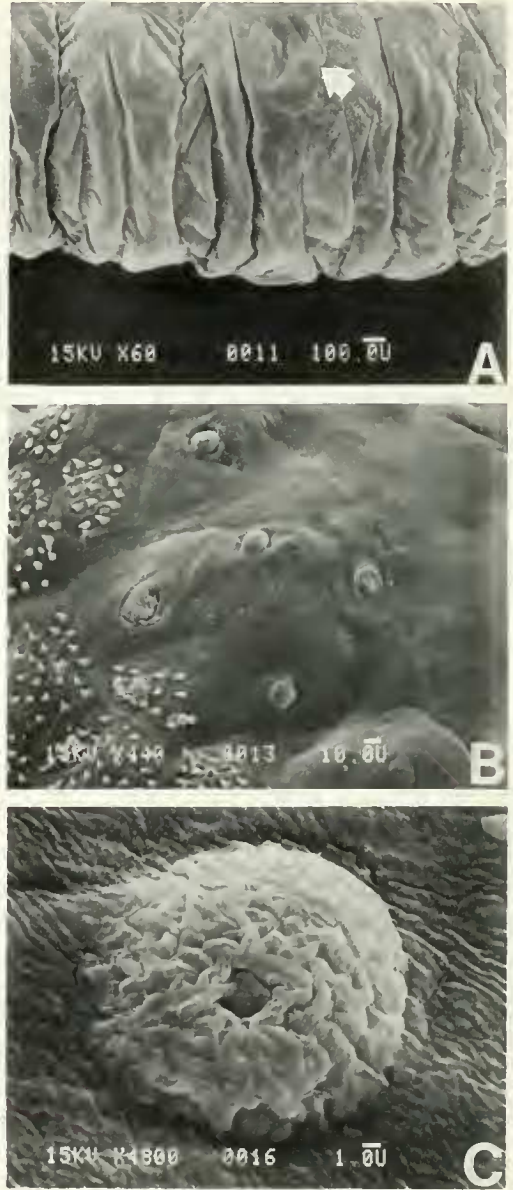


Fig. 4. Third instar larva of *St. affinis*. (A) Venter, arrow denotes depressions along segmental lines; (B) lateral grouping of sensilla; (C) detail of middle, wart-like sensillum.

5.7 ± 0.15 mm in length and 2.5 ± 0.06 mm in widest width. The puparium is translucent, oblong, barrel-shaped, rounded at both ends, and smooth. Prior to eclosion the pharate adult is easily visible through

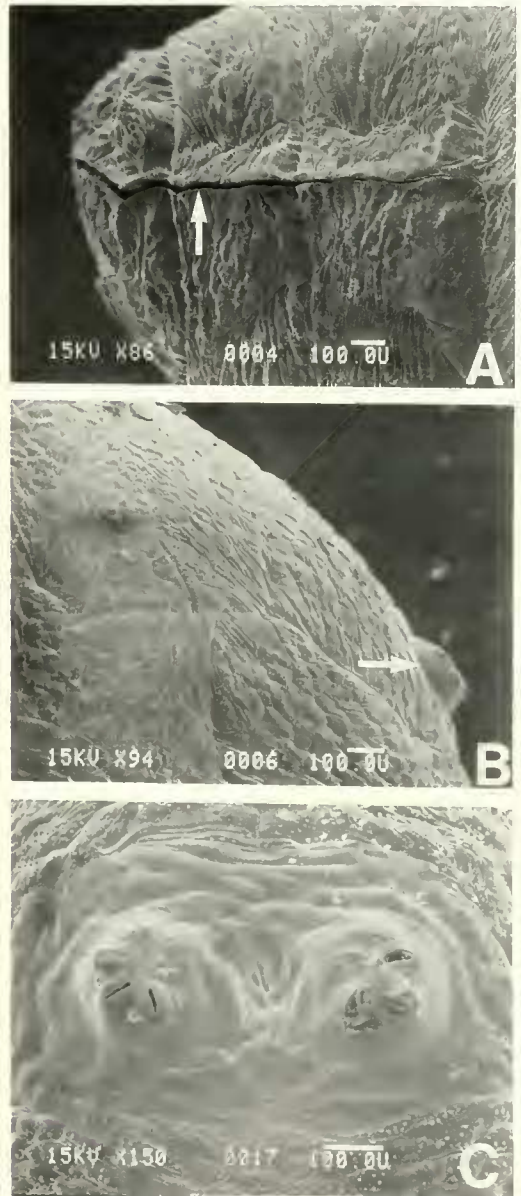


Fig. 5. Second instar larva of *St. affinis*. (A) Habitus; (B) gnathocephalon; 1—median oral lobe; 2—lateral sensory organ; (C) anterior thoracic spiracle.

Fig. 6. Puparium of *St. affinis*. (A) Anterior end, arrow denotes lateral fracture line; (B) posterior end, arrow denotes raised posterior spiracles; (C) posterior spiracles.

the puparial integument; it was also noted that the wings of the adults were fully pigmented within the puparia. The anterior end bears the open anterior thoracic spiracles, and the lateral fracture line which extends posteriorly for three segments (Fig. 6A, ar-

row). The posterior spiracular plates slightly protrude dorsal to the transverse midline (Fig. 6B, arrow); the rimae are elongate-oval; the spiracular slits are ca. 0.05 mm long; and the interspiracular processes are small and lack well-defined blades (Fig. 6C).

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